BALLAST WATER DISCHARGE STANDARDS

REPORT AND RECOMMENDATION OF THE CALIFORNIA ADVISORY PANEL ON BALLAST WATER PERFORMANCE STANDARDS

SUMMARY OF ADVISORY PANEL RECOMMENDATION

The Advisory Panel recommends that the State of California adopt the ballast water discharge standards described below in order to reduce the introduction of harmful exotic species into California's coastal waters. The recommended standards are more stringent than those proposed in either the International Maritime Organization (IMO) Convention or in legislation introduced in the U.S. Senate because the Panel has determined that those standards are inadequate to prevent the introduction of new exotic species that could have significant damaging impacts on California's aquatic ecosystems and on its economy.

Existing technologies are capable of achieving the recommended standards. The primary challenge is to adapt these technologies for application to the conditions and operational requirements of ballast water discharges. To accomplish this in an orderly and economical manner, the Panel recommends a phased and tiered implementation approach consistent with other proposals.

The Panel's recommendation was adopted by a majority of the Panel members. Members representing the shipping industry stated that they recommend alignment with State and federal standards so the shipping industry does not have to deal with different discharge requirements in different parts of the country. They therefore felt they could not endorse the majority recommendation because it differs from standards contained in pending Senate legislation. (Minority opinions are included in the Appendix.)

The Panel did not have time or resources to consider many key aspects of implementing discharge standards, including program funding, monitoring of discharges, environmental monitoring and assessment of program effectiveness. It would be helpful to either reconvene this Panel or to convene a new independent panel of appropriate expert and stakeholder parties to make recommendations on these issues.

LEGISLATIVE AUTHORITY

California Public Resources Code §71204.9 directed the State Lands Commission (Commission) to convene an Advisory Panel to make recommendations to the Commission regarding the content, issuance and implementation of performance standards for the discharge of ballast water into the waters of the state, or into waters that may impact waters of the state. The standards are to protect the beneficial uses of affected and potentially affected waters, based on the best available technology economically achievable. The State Lands Commission is to consider the Advisory Panel's recommendations in submitting recommendations on ballast water standards to the Legislature by January 31, 2006.

The Advisory Panel consisted of representatives from the shipping industry, from stakeholder industries that are affected by exotic species introduced in ballast water discharges, from environmental organizations, scientific experts, and representatives from state and federal agencies (Appendix 1). The Panel met five times in the spring and summer of 2005.

BRIEF OVERVIEW OF THE CHALLENGE

It is not necessary here to revisit in detail the nature of the ecological and socio-economic problems caused by invasive aquatic organisms. The impacts of those invasions have been well documented and demand an effective response. It became clear during panel deliberations that an unacceptable level of invasions will continue over the coming years unless more effective measures of prevention are implemented. Due to inherent limits on its effectiveness, ballast water exchange or retention (which are the basis for California's current regulatory approach) cannot prevent new invasions from occurring.

The question therefore became, what is the standard of treatment needed to reduce the number of viable organisms in ballast water discharges to a level that lowers the risk of invasion to an acceptable threshold? The Panel and State Lands Commission staff assembled data and consulted experts to guide the Panel's consideration of this question.

ADVISORY PANEL RECOMMENDATION

The Advisory Panel recommends that California adopt the discharge standards in Table 1 in order to reduce the risk of introduction of new exotic species to an acceptable level. The Interim Standards should be phased in according to the schedule in Table 2, which is the same implementation schedule as contained in the IMO Convention and in pending Congressional legislation. The Long-term Standard of no detectable discharge of living organisms should undergo a technical review by 2016 to determine if this goal can reasonably be achieved and recommend an appropriate implementation schedule.

It is expected that private industry will play the main role in developing effective technologies once standards are adopted; and that industry will be given broad leeway to determine what technologies to use as long as the chosen method complies with the standards and all other applicable regulatory requirements. The Panel's shipping industry representatives expressed interest in having the State certify technologies that achieve the applicable standards.

Table 1. Recommended ballast water discharge standards

	Organism type or size class	Discharge standard
Interim Standards	*Environmentally-protective limits*	
	Organisms greater than 50 microns in minimum dimension:	No detectable living organisms
	Organisms 10-50 microns in minimum dimension:	No more than 10^{-2} living organisms per milliliter
	Organisms less than 10 microns in minimum dimension:	No more than 10^{3} colony-forming-units of bacteria per 100 milliliters
		No more than 10^{4} viruses per 100 milliliters
	Public health-protective limits	
	Escherichia coli:	No more than 126 colony-forming-units per 100 milliliters
	Intestinal enterococci:	No more than 33 colony-forming-units per 100 milliliters
	Toxicogenic *Vibrio cholerae* (serotypes O1 and O139):	No more than 1 colony-forming-unit per 100 milliliters
		No more than 1 colony-forming-unit per gram of wet zoological samples
Long-term Standard	All size classes	No detectable living or culturable organisms

Table 2. Recommended Implementation Schedule for Interim Standards

Ballast capacity of vessel	Applied to vessels in this size class that are constructed in or after	Applied to other vessels in this size class starting in
<1500 metric tons:	2009	2016
1500-5000 metric tons:	2009	2014
>5000 metric tons:	2012	2016

RATIONALE FOR THE RECOMMENDED STANDARDS

After some discussion, the Panel agreed to consider standards that set limits on organism concentrations in ballast water discharges within the organism size classes and on the implementation schedule used in the IMO Convention and in the current drafts of two bills pending in the U.S. Senate (S. 363 and S. 1224). As noted by the Panel's shipping industry representatives, this implementation schedule takes into account the limited availability of dry-dock facilities and provides a workable time frame for scheduling vessels for retrofit. Adopting this framework also provides a measure of consistency with national and international efforts to set ballast water discharge standards.

Within this framework, the Panel considered a range of concentration standards including the proposed IMO standards, the standards in the pending Senate bills, the standards advocated by the U.S. representatives to the IMO conference, a standard based on reducing the rate of invasion due to ballast water discharges to a level approximating the natural invasion rate, and various forms of zero discharge standards. The Panel compared these, on an order-of-magnitude basis, to the mean and median values for organism concentrations in untreated ballast water discharges, as determined from various studies. These figures are shown in the first table in Appendix 2.

Biological Basis for Standards

The Panel was unable to find any written or reported explanation of the biological rationale for the concentration standards in the IMO Convention, the standards in the pending Senate bills, or the standards advocated by U.S. representatives at the IMO Convention. While these standards appear to have been derived in part from technical workshops convened by the U.S. Coast Guard or IMO, the published materials from these workshops do not give any explanation or indication of the effect that these standards are expected to have on the rate of invasions due to ballast water discharges (USCG 2002; MEPC 2003). In some cases, it's not clear if these standards would result in a significant reduction from current, untreated discharge levels (*e.g.* compare the IMO standard for the 10-50 micron size class with untreated concentrations, in Appendix 2, Table 1).

The scientific basis for a standard of discharging no exotic organisms is that exotic organisms, unlike conventional chemical pollutants, can reproduce and increase over time, persist indefinitely and spread over large regions. Thus, very large, widespread and long-term impacts could potentially result from the discharge of a small number of individual organisms—in some cases as few as a single mated pair, or in the case of asexually-reproducing species, a single individual. From this perspective, the only biologically safe standard is no discharge of exotic organisms. The Panel noted that in practice "zero discharge" might refer to a variety of distinct standards, including no detectable discharge of organisms, no discharge of viable organisms, and no discharge of ballast water. Additional information on zero discharge standards is provided in the memo in Appendix 3.

One biologically-based standard that is less stringent than zero discharge is a "natural invasion rate standard," which would reduce the discharge of organisms in ballast water to a level where the rate of invasion due to these discharges is approximately equal to the natural invasion rate. The calculation of concentration limits to meet this standard starts with estimates of the concentration of organisms in untreated and unexchanged ballast water (Appendix 4), and reduces these by the ratio between the natural invasion rate and the rate of invasion due to ballast water discharges (Appendix 5). The Panel's scientist members offered different estimates of the natural invasion rate, and the Panel considered the range of these estimates in developing its recommendations (Appendix 6).

Technical and Economic Considerations

The basic task involved in meeting ballast water discharge standards is to remove or kill organisms contained in a tank of water. Several technologies are available to achieve this, including methods used by municipalities to disinfect large quantities of water and wastewater. These technologies need to be adapted to work on the variety of organisms present in ballast water, over the range of physical and chemical parameters that are characteristic of ballast water, and to function in a shipboard setting or onshore system in a manner that is consistent with ship operational requirements.

Relative to the quantity of water and wastewater that is routinely disinfected by municipal and other treatment plants, the volume of ballast water discharged in California is quite small. For example, the total ballast water discharge in California in 2004 (7.8 million m^3—Falkner *et al.* 2005) is less than 0.25% (one-quarter of one percent) of the volume of wastewater that is annually treated and discharged into the San Francisco Bay Estuary (Gunther *et al.* 1987). If it were gathered together in one place, all the ballast water discharged in California could be treated in one small treatment plant.

The Panel was able to consider some limited information regarding the shipping industry's ability to finance the investment in new ballast water treatment technologies. Preliminary cost estimates for ballast water treatment range from less than \$10 million to \$50 million per year to treat all the ballast water discharged into California (see page 2 of the memo in Appendix 7). One study commissioned by the California Association of Port Authorities estimated total capital and operating costs of \$8.1 million/year to collect and treat all ballast water discharges in California in onshore plants built specifically for that purpose (URS/Dames & Moore 1998). The study found that the pipes and tanks needed to transport and store the ballast water on shore formed the major part of these costs, with the treatment plants themselves accounting for 7% of the total.

In comparison, the existing capital and operating costs for a single ship are estimated at \$10,000-\$53,000 per day (≈\$4-19 million/year) and the profits for a single ship at \$3,000-\$38,000/day (\$1-14 million/year); a federally-subsidized dredging project at the Port of Oakland is estimated to provide \$156-229 million/year in net direct benefits to the ships using that port; and the cargo handled by California ports is valued at over a quarter of a trillion dollars each year (Appendix 7, page 3). The California shipping industry is currently undergoing an expansion related to globalization and the ongoing growth in international trade, with the industry as a whole yielding record-high profits (Appendix 7, pages 3-4). Thus, economic indicators suggest that the shipping industry may have the financial capacity to provide high levels of ballast water treatment, and that the timing may be appropriate for such investment.

The economic indicators cited here and in the Appendix were compiled by Panel members and State Lands Commission staff from literature and internet searches and discussions with economists. More comprehensive financial information on the industry may be available, which would allow for a more detailed comparison between the estimated costs for treating ballast water discharges and the industry's capacity to pay these costs. This information was not available to the Panel.

Recommended Standard for Organisms >50 Microns in Minimum Dimension

A treatment system using 50-micron filters would eliminate all or virtually all organisms with a minimum dimension greater than 50 microns. Filters of this size have been used and performed reliably in several ballast water treatment studies and are expected to be a component of various ballast water treatment systems planned for shipboard use (Appendix 3). Some ballast water studies and proposed treatment systems have involved 10-micron to 25-micron filters, but the performance and compatibility of these finer filters with ship operational requirements is not yet clear. The USCG and IMO technical workshops recommended that standards of complete removal or inactivation, no discharge, or no detectable discharge of organisms >50 microns in minimum diameter (or in some cases, even smaller organisms) be put into effect by 2006, and one workshop recommended that a further standard of no detectable discharge of organisms >10 microns in minimum diameter be put into effect by 2015 (Appendix 3). The Panel found that a standard of no detectable discharge of organisms >50 microns in minimum diameter is feasible, and therefore recommended that this be adopted as an Interim Standard for implementation between 2009 and 2016.

Recommended Standard for Organisms 10-50 Microns in Minimum Dimension

Based on the information noted in the preceding paragraph, the Panel was uncertain whether a standard of no detectable discharge of organisms 10-50 microns in minimum diameter is feasible in the short term. Instead, the Panel determined that a feasible short-term standard could be based on the less stringent end of the range of estimates of a natural invasion rate standard (Appendix 5). The Panel therefore recommended that an Interim Standard for this organism size class of no more than 0.01 living organisms per milliliter of ballast water discharge be implemented between 2009 and 2016, and that the State evaluate by 2016 when a Long-term Standard of no detectable discharge could be implemented. The Panel noted that the recommended Interim Standard for this organism size class is the same as the standard advocated by the U.S. representatives to the IMO conference.

Recommended Standard for Organisms <10 Microns in Minimum Dimension

While 0.2-micron membrane filters have been used in drinking water treatment systems, filter systems for removing organisms <10 microns in minimum dimension from ballast water have not been tested and are unlikely to be feasible in the short-term for widespread ballast water treatment. Instead, the Panel determined that a feasible short-term standard for this size class could be based on a 10^5-fold reduction in the concentration of organisms relative to their mean concentration in untreated and unexchanged ballast water, consistent with the middle of the range of estimates of a natural invasion rate standard (Appendix 5). The Panel noted that implementing this level of reduction over the next decade seems reasonable relative to the 10^3-fold or 10^4-fold reductions in microbe concentrations required by the federal Safe Drinking Water Act, which have been in place and successfully implemented for decades. The Panel therefore recommended that an Interim Standard of no more than 10^3 bacteria and no more than 10^4 viruses per 100 milliliters of ballast water discharge be implemented between 2009 and 2016, and that the State evaluate by 2016 when a Long-term Standard of no detectable discharge could be implemented.

Recommended Standard to Protect Public Health

The Senate bills (S. 363 and S. 1224) contain concentration limits for certain pathogens and pathogen indicator species. These are based in part on the U.S. EPA water quality criteria for water contact recreation (standards for *Escherichia coli* and intestinal enterococci), and in part on evidence that ballast water has transported epidemic strains of the bacterium that causes cholera (standards for *Vibrio cholerae*). Although one Panel member argued that the water contact recreation criteria were insufficiently protective of public health, the Panel found that the public health protective standards in these Senate bills were reasonable and feasible and recommended that they be adopted as an Interim Standard.

CONCLUSION

The Advisory Panel strove to identify an approach to reduce the risk of harmful invasions of exotic species that was scientifically based, effective and reasonable. The recommended approach is the same as recently proposed federal and international approaches in terms of implementation schedule, organism size classes, health indicator organisms, allowable technologies and application to various classes of ships. It differs from other approaches in that it proposes more stringent limits on the number of viable organisms that would be allowed in ballast water discharges. The Panel recommends these more stringent limits because it concluded that other adopted and proposed standards would fail to accomplish the objective of preventing the introduction of potentially harmful organisms. Because the environmental and socio-economic impacts of invasive species have been so significant to date, the Panel believes that strong standards are essential to the success of a preventive strategy.

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LIST OF APPENDIXES

APPENDIX 1: ADVISORY PANEL MEMBERS

Marian Ashe and Steve Foss
California Department of Fish and Game

John Berge
Pacific Merchant Shipping Association

Dave Bolland and Steve Hall
Association of California Water Agencies

Brad Chapman
Chevron Shipping Company LLC

Andrew Cohen
San Francisco Estuary Institute

Andrea Fox
California Farm Bureau Federation

Jeff Herod
U. S. Fish and Wildlife Service

Marc Holmes
The Bay Institute

Bill Jennings
The DeltaKeeper
California Sportfishing Protection Alliance

Steve Moore
San Francisco Bay Regional Water Quality Control Board

Sarah Newkirk
Ocean Conservancy

Greg Ruiz
Smithsonian Environmental Research Center

Scott Smith
Washington Department of Fish & Wildlife

Lisa Swanson
Matson Navigation

Mark Sytsma and Christina Simkanin
Portland State University

Drew Talley
San Francisco Bay National Estuarine Research Reserve

Kim Ward
State Water Resources Control Board

Nick Welschmeyer
Moss Landing Marine Laboratory

APPENDIX 2: COMPARISON OF POTENTIAL STANDARDS

Table 1. Order-of-magnitude comparison of organism concentrations in ballast water and potential discharge standards

Organism Size Class	Units	Concentration in untreated, unexchanged ballast water	Standard in IMO Convention	Standard in Senate Bills	US position at IMO conference	Standard based on natural invasion rate	Zero discharge standard
>50 µm	$/m^3$	10^2-10^3	10	10^{-1}	10^{-2}	10^{-3}-10^{-2}	0
10-50 µm	/mL	10-10^2	10	10^{-1}	10^{-2}	10^{-4}-10^{-3}	0
<10 µm	/100 mL	10^8-10^9	–	–	–	10^3-10^4	0

Table 1 compares the organism concentrations in untreated ballast water discharges and a range of potential concentration standards for ballast water discharges.

Columns 1-2: The organism size classes and units are those used in the IMO Convention and in the current drafts of two bills in the U.S. Senate (S. 363 and S. 1224). The organism size classes refer to the minimum dimensions of the organisms.

Column 3: The concentrations in untreated and unexchanged ballast water are order-of-magnitude estimates based on statistical summaries of a range of studies, which are described further in Table 2 below. For the >50 micron and 10-50 micron organism size classes, the ranges approximate the median and mean values for zooplankton and phytoplankton respectively; for the <10 micron size class, the range approximates the mean values for bacteria and virus-like particles, respectively.

Columns 4-6: The IMO Convention, Senate bills and the standards advocated by the U.S. representatives at the IMO conference include public health protective standards that limit the concentration of certain pathogenic and pathogen indicator species that are less than 10 microns in minimum dimension, but do not contain any general restriction on the discharge of organisms in this size class to protect the environment from invasions. The full standards in the IMO Convention and Senate bills are given in Table 3 below.

Column 7: The ranges given for a standard based on the natural invasion rate are based on a 10^5-fold reduction from the range of concentrations given for untreated, unexchanged ballast water. Scientists on the Panel or consulted by Panel members estimated that the appropriate reduction could be between 10^4-fold and 10^6-fold, based on their range of estimates of the natural invasion rate. This range could raise or lower the figures in Table 1 by one order of magnitude.

Column 8: Several types of zero discharge standard were discussed by the Panel, including no discharge of ballast water, no discharge of living organisms, and no detectable discharge of living organisms.

Table 2. Organism concentrations in untreated and unexchanged ballast water

Type of Organism	Number of Ships Sampled	Median Concentration	Mean Concentration
Zooplankton	429	0.4/liter	4.64/liter
Phytoplankton	273	13,300/liter	299,202/liter
Bacteria	11		8.3×10^8/liter
Virus-like Particles	7		7.4×10^9/liter

Table 2 shows the IMO's statistical data on organism concentrations in ships' ballast water (MEPC 2003). These data were the basis for the order-of-magnitude concentrations given in Column 3 of Table 1, and were derived from studies that sampled ballast water of coastal origin with a broad range of ages that had not been exchanged or treated. MEPC (2003) suggested that median values are a useful frame of reference for considering ballast water standards (the definition of median is that half the tanks had higher concentrations than the median value, and half had lower.)

Table 3. IMO Convention and Senate Bill standards for permissible concentration limits in ballast discharges

Organism Type or Class	IMO Convention	S. 363 and S. 1224
Living organisms >50 microns in minimum dimension	10/m^3	0.1/m^3
Living organisms 10-50 microns in minimum dimension	10/mL	0.1/mL
Colony-forming units of *Escherichia coli*	250/100 mL	126/100 mL
Colony-forming units of intestinal enterococci	100/100 mL	33/100 mL
Colony-forming units of toxicogenic *Vibrio cholerae* (serotypes O1 & O139)	1/100 mL	1/100 mL
Colony-forming units of toxicogenic *Vibrio cholerae* (serotypes O1 & O139)	1/gram wet weight of zoological samples	1/gram wet weight of zoological samples

References

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APPENDIX 3: MEMO ON ZERO DISCHARGE STANDARDS

Subject: **Background and Possible Basis for a Zero Discharge Standard**
To: Ballast Water Treatment Standards Committee
From: Andrew Cohen
Date: August 4, 2005

Various standards might be considered zero discharge standards, including:
- no detectable discharge of living organisms
- zero discharge of living organisms
- no discharge of ballast water

The scientific basis for a zero discharge standard is that exotic organisms, unlike conventional chemical pollutants, can:
1) reproduce and increase over time:
2) persist indefinitely: and
3) spread, sometimes in high concentrations, over very large and even continental distances once they have been discharged to a new continent.

Such invasions can result from a single pair of mated organisms, or in the case of asexually-reproducing species, a single individual. An example of the latter is the tropical seaweed *Caulerpa taxifolia*, whose invasion over thousands of acres in the Mediterranean Sea and in two bays in California consists of a single clone, and thus derives from a single individual.[1]

In 1998, the San Francisco Bay Regional Water Quality Control Board (Region 2) proposed and the State Water Resources Control Board approved listing exotic species discharged in ballast water as a priority pollutant impairing the waters of San Francisco Bay, under Clean Water Act §303(d) (SFBRWQCB 1998). In subsequently considering how to set a total maximum daily load (TMDL), Region 2 concluded (at least informally) that zero-discharge of exotic organisms was the only scientifically-supported standard available.

The U.S. Coast Guard convened two technical workshops on Ballast Water Treatment Standards in the spring of 2001, bringing together experts in the fields of ballast water treatment, invasion biology and standards development. The East Coast Workshop recommended a long-term (within 5 years) standard of 100% removal or inactivation of coastal holoplankton, meroplankton, and demersal organisms (including all life stages) and photosynthesizing organisms (including phytoplankton, cysts and algal propagules), which

[1] The import and sale of *Caulerpa taxifolia*, dubbed the "Killer Alga," was banned in the U.S. in response to a petition from over 100 scientists who were alarmed at its impacts in the Mediterranean. It was subsequently discovered growing in two small bays in California, where its eradication (which is nearly complete after 4 years of effort) probably cost over $10 million (Raloff, 1998, 2000; Jousson *et al.* 2000).

includes a variety of organisms down to 2 μm in size. The West Coast Workshop recommended a short-term (within a few years) standard of zero discharge for organisms >50 μm and a long-term (within 10 years) standard of zero discharge for all organisms (USCG 2002a).

Based on these workshops, meetings of the Ballast Water and Shipping Committee of the Aquatic Nuisance Species Task Force, and an IMO GloBallast workshop, the U.S. Coast Guard published an Advance Notice of Proposed Rulemaking in the spring of 2002 (USCG 2002b). This notice listed alternative short-term standards, including removing, killing or inactivating all organisms >100 μm, and no discharge of organisms >50 μm; and alternative long-term goals, including no discharge of zooplankton and photosynthetic organisms (including holoplanktonic, meroplanktonic, and demersal zooplankton, phytoplankton, and propagules of macroalgae and aquatic angiosperms), inclusive of all life-stages.

An International Workshop on Ballast Water Discharge Standards was held by the State Department and the U.S. Coast Guard at NSF headquarters on Feb. 12-14, 2003. Participants included IMO representatives and technical experts from 7 IMO member states. Of the Workshops three working groups, Group 1 recommended an initial standard of no detectable organisms >50 μm; and Group 3 recommended an initial standard of no detectable organisms >100 μm to go into effect by 2006, no detectable organisms >50 μm to go into effect by 2009, and no detectable organisms >25 μm to go into effect by 2015. A synthesis of the groups' recommendations was suggested, which included a standards of no detectable organisms >50 μm to go into effect by 2006, and no detectable organisms >10 μm to go into effect by 2015 (MEPC 2003).

Several assessments and studies of ballast water treatment have employed filtration either as the initial or sole treatment process. The filter sizes used in these assessments range from 150 μm to 50 μm or less,[2] suggesting that zero detectable discharge of organisms above these sizes would be routinely achieved by these treatments.

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[2] Some examples of ballast treatment systems using filtration that have been investigated include:
• *filtration to 150 μm*: a single-pass 150 μm wedgewire strainer on ballasting at 1,250 and 2,500 m^3/hr (Pollutech 1992); a single-pass 150 μm wedgewire strainer on ballasting at 2,500 m^3/hr and UV at 420 mW-S/cm^2 (Pollutech 1992); a recirculating system with 150 μm wedgewire strainer and UV at 420 mW-S/cm^2 (Pollutech 1992);
• *filtration to 100 μm*: a continuous deflective separation unit operated at normal ballast pump flow rates filtering to 50-100 μm (Victoria ENRC 1997); 100 μm filtration at 270 and 1,800 m^3/hr, with UV, thermal or ultrasonic treatment (Battelle 1998); a self-cleaning 100 μm filter at 135 m^3/hr (Röpell & Voight 2002);
• *filtration to 50 μm*: a single-pass 50 μm wedgewire strainer on ballasting at 1,250 and 2,500 m^3/hr (Pollutech 1992); a single-pass 50 μm wedgewire strainer on ballasting at 2,500 m^3/hr and UV at 210 mW-S/cm^2 (Pollutech 1992); an in-line 50 μm stainless steel strainer with automatic backwash (AQIS 1993); 50 μm filtration during ballasting (Dames & Moore 1999); continuous backwash filtration to remove particles and organisms down to 50 μm size (URS/Dames & Moore 2000); a 50 μm filter screen at 340 m^3/hr with and without a prefilter (Cangelosi & Harkins 2002); a self-cleaning 50 μm filter at 135 m^3/hr (Röpell & Voight 2002); a self-cleaning 50 μm screen at 340 m^3/hr (Waite & Kazumi 2004);
• *filtration to 25 μm*: a self-cleaning 25 μm woven mesh screen filter at 1,000 m^3/hr (Carlton *et al*. 1995); 25 μm filtration at 270 and 1,800 m^3/hr, with UV, thermal or ultrasonic treatment (Battelle 1998); a 25 μm filter screen at 340 m^3/hr with and without a prefilter (Cangelosi & Harkins 2002);
• *filtration to 20 μm*: 20 μm filtration during ballasting (Dames & Moore 1999); 20 μm filtration and cyclone during ballasting (Dames & Moore 1999).

Until 1992, the largest containerships built were of the Panamax type, with widths no greater than the 106' maximum that is permitted to pass through the Panama Canal. As containerships tried to carry greater numbers of containers per ship, containers were stacked progressively higher on the decks through the 1980s, with correspondingly increasing amounts of ballast water needed to provide stability. Beamier Post-Panamax containerships, which increasingly dominate the fleet,[3] are inherently more stable and carry and discharge much less ballast water per voyage—on the order of a few hundred tons rather than several thousand tons for Panamax ships (Herbert Engineering 1999)—while carrying much larger numbers of containers. Some can also shifting ballast internally to adjust the ship's list and trim. Ship designers are considering further modifications to ships' piping systems that would eliminate the discharge of ballast water in port (Herbert Engineering 1999; Schilling 2000). This may also be feasible for a few other types of vessels, such as passenger ships (Schilling 2000).

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Dames & Moore (1999) concluded that on-board filtration systems appear "potentially viable with filter sizes between 20 and 50 μm". Oemcke (1999) noted that self-cleaning stainless steel screens can filter down to 10-20 μm without flocculants, and that membrane filters to filter surface waters down to 0.2 μm cost 35-49¢ per m^3 of filtrate in 1990 (*i.e.* $2.7-3.8 million to filter the 7.8 million m^3 of ballast water discharged in California in 2004), but that costs had been dropping as technology improved and market share increased.

[3] The Port of Oakland projects that Post-Panamax sized containerships, which accounted for 10% of port visits in 1996, will account for 75% of port visits in 2010 (Port of Oakland 1999).

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APPENDIX 4: CONCENTRATIONS OF ORGANISMS DELIVERED IN SHIPS' BALLAST WATER IN THE ABSENCE OF ANY TREATMENT: ESTABLISHING A BASELINE FOR CONSIDERATION OF TREATMENT EFFICACY –

A report submitted to the Marine Environmental Protection Committee (MEPC) of the International Maritime Organization (IMO) by the ICES/IOC/IMO Study Group on Ballast Water and other Ship Vectors, on behalf of the International Council for the Exploration of the Sea (ICES), based on data assembled from Study Group members by Dr. Greg Ruiz of the Smithsonian Environmental Research Center.

INTERNATIONAL MARITIME ORGANIZATION

IMO

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MARINE ENVIRONMENT PROTECTION COMMITTEE
49th session
Agenda item 2

MEPC 49/2/21
23 May 2003
Original: ENGLISH

HARMFUL AQUATIC ORGANISMS IN BALLAST WATER

Comments on draft Regulation E-2
Concentrations of organisms delivered in ships' ballast water in the absence of any treatment: Establishing a baseline for consideration of treatment efficacy

Submitted by the International Council for the Exploration of the Sea (ICES)

SUMMARY	
Executive summary:	This document has been submitted by the Chairmen of the ICES/IOC/IMO Study Group on Ballast Water and other Ship Vectors (SGBOSV), Stephan Gollasch (Germany) and Steve Raaymakers (IMO GloBallast Programme Co-ordination Unit), on behalf of the International Council for the Exploration of the Sea (ICES). This submission is based on the meeting of SGBOSV, held in March 2003 in Vancouver, Canada. The Study Group discussed the basis of the bracketed numbers in the draft Regulation E-2 and developed a database of known organism concentrations in ballast tanks, so as to guide the scientific determination of ballast water management standards. These data establish a current baseline level or threshold of organism delivery, against which treatment and management efficacy should be measured. The proposed ballast water treatment/ management should result in a substantial reduction below the current baseline level of organism concentrations delivered in untreated ballast tanks. The full meeting report of the 2003 meeting of SGBOSV will soon be available at www.ices.dk. The content of this submission does not necessarily represent the views of ICES.
Action to be taken:	Paragraph 12
Related documents:	MEPC 48/2; MEPC 48/2/1; MEPC 49/2/3

Introduction

1 Mr. Michael Hunter (United Kingdom), Chairman of the Ballast Water Working Group convened during MEPC 48, requested scientific input to provide a scientific reasoning for the individual numbers in draft Regulation E-2.

2 The second Intersessional Meeting of the Ballast Water Working Group (IBWWG) discussed Regulation E-2 and recommended a new format for consideration at MEPC 49:

> "Ships conducting Ballast Water Management in accordance with this Regulation shall discharge no more than [25] viable individuals per litre of zooplankton greater than [10]µm in size; and no more than [200] viable cells per ml of phytoplankton greater than [10]µm in size; and discharge of a specified set of indicator microbes shall not exceed specified concentrations".

3 The Ballast Water Working Group concluded that there was not sufficient time and scientific resources at the MEPC-IBWWG to determine the specific size and concentration in brackets. Some concern was expressed that the individual numbers in brackets for both, total phytoplankton and zooplankton abundance may not provide meaningful protection of species invasions (MEPC 49/2/3, paragraphs 2.63 to 2.65).

4 SGBOSV agreed that the finalisation of this standard is vital so as to provide the R&D community with a clear benchmark to aim for in developing alternative treatment technologies. It was also made clear that organism concentration values currently inserted in the draft standard are subject to negotiation. Expert scientific input is urgently required to inform this process and ensure that scientifically defensible and environmentally meaningful values are adopted in the Convention.

5 Identification of specific standards for ballast water treatment remains unresolved. It is certain that removing all organisms from ballast water would prevent associated invasions. It is also clear that reducing organism concentrations will reduce the likelihood of invasions. However, the specific level of reduced invasion risk achieved with each incremental reduction in organism concentration is presently not known.

6 As a minimum standard, to achieve any reduction in invasion risk, ballast water treatment must result in a substantial reduction in the concentrations of organisms compared to untreated ballast water. In particular, treatment should reduce the concentrations of coastal organisms, which can colonize and significantly impact coastal (including marine, brackish and freshwater) ecosystems.

7 This document summarizes data on the concentrations of viable organisms that arrive in ballast water that has not undergone any treatment or management. This is intended to characterize the current level of delivery against which treatment and management efficacy (standards) should be considered.

Executing Institutions

8 The Study Group on Ballast Water and Other Ship Vectors (SGBOSV) is a joint activity of ICES, IMO and IOC. The SGBOSV is composed of an international group of scientists, with extensive knowledge about the biology of ship-mediated transfers and invasions. The SGBOSV strives to advance scientific understanding of biological invasions associated with ships that is needed to guide management and policy decisions.

9 At the 2003 meeting of SGBOSV in total 41 participants from Australia, Belgium, Canada, France, Germany, Ireland, Italy, the Netherlands, New Zealand, Norway, Russia, Sweden, the United Kingdom, the United States of America and the GloBallast Programme (GloBallast), International Maritime Organization (IMO) attended (Annex 4). The Chairman of

the IMO Ballast Water Working Group, Mr. Michael Hunter, who also attended the 2003 meeting of SGBOSV, appealed to the Study Group to provide advice and input, in time for consideration by MEPC 49. Responding to the need for scientific input, and as requested by Mr. Hunter, SGBOSV discussed the bracketed individual numbers in draft Regulation E-2.

Methodology

10 Study Group member Dr. G. Ruiz of the Smithsonian Environmental Research Center, United States volunteered to take the lead in developing a global database on organism concentrations based upon data provided by Study Group members. A questionnaire addressing concentrations of organisms measured in the ballast water of commercial vessels was sent to the members of SGBOSV shortly after the meeting.

11 The information provided was summarized and is attached as annex 1 to this document. SGBOSV hopes that the datasets will support the development of ballast water standards of the Ballast Water Convention.

Action requested of the Committee

12 The Committee is requested to take the data provided in the annexes to this document into account and comment, as it deems appropriate.

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ANNEX 1

1 The ICES/IOC/IMO SGBOSV discussed the basis of the bracketed numbers in the draft Regulation E-2 and agreed that it is necessary to consider the concentrations of organisms in ballast tanks. This provides an important framework to understand the transfer of biota and to guide the development of ballast water treatment standards.

2 The SGBOSV has developed a database to characterize the concentrations of organisms measured in ballast tanks.

3 The information of this database is summarized here and intended to provide a baseline measure of what arrives in ballast water without any treatment, to better inform discussions at IMO.

Methodology

4 Data were included only for ballast water of coastal origin (< 100 km offshore) that was not exposed to ballast water exchange or an alternate treatment. These data included ballast water sampled from multiple vessel types (tankers, bulk carriers, container vessels, etc.) and with a broad range of ages.

5 The concentrations of organisms were summarized according to four general taxonomic groups: zooplankton, phytoplankton, bacteria, and virus-like-particles. These data derive from multiple studies, conducted at various ports, encompassing all seasons. The sources of data, and details of methods, are shown in annex 2.

6 These data are restricted to the ballast water only and do not include estimates for sediments or biofilms.

7 Summary statistics were calculated for each taxonomic group, to characterize the concentration of organisms present in untreated ballast water.

Results

8 For ***zooplankton***, summary statistics are based upon n=429 ballast tanks sampled (see Annex 3), mostly from individual vessels (i.e., a single tank at the end of independent vessel voyage), as follows:

(a) The median was 0.4 individuals per litre, indicating that half of the samples had concentrations above this value and the other half below this value.

(b) The mode was 0.1 individuals per litre. The mode is simply the individual value (concentration) most commonly observed among all samples, compared to any other single value.

(c) The mean number of zooplankton was 4.64 individuals per litre (standard error =0.708).

(d) The range of concentrations was 0 - 172 individuals per litre.

(e) These values are a conservative estimate of concentrations because samples were collected with nets with mesh openings that ranged from 55-80 μm and so only zooplankton larger than the mesh size were collected.

(f) The frequency distribution of zooplankton concentrations is shown in Figure 1 (annex 3).

9 For ***phytoplankton***, summary statistics are based upon n=273 ballast tanks sampled (see annex 3), mostly from individual vessels (i.e., a single tank sampled at the end of independent vessel voyages), as follows:

(a) The median was 13,300 phytoplankton cells per litre, indicating that half of the samples had concentrations above this value and the other half below this value.

(b) The mode was 1.0 phytoplankton cells per litre. The mode indicates the individual value most commonly observed among all samples, compared to any other single value.

(c) The mean number of phytoplankton was 299,202 phytoplankton cells per litre (standard error = 183,637).

(d) The range of concentrations was 1 - 49,716,400 phytoplankton cells per litre.

(e) These values are a conservative estimate of concentrations for phytoplankton above 10 μm, because samples were sieved with mesh sizes that ranged from 0-10 μm (0 means samples were not concentrated).

(f) The frequency distribution of phytoplankton concentrations is shown in Figure 2 (annex 3).

10 Fewer data were available for concentrations of ***bacteria*** and ***virus-like-particles*** in ballast water, limiting characterization in a similar fashion to zooplankton and phytoplankton. Instead, we simply report mean values and ranges.

(a) The mean number of bacteria from n=11 ballast tanks was 8.3×10^8 cells per litre (standard error = 1.7×10^8), ranging from 2.4×10^8 to 1.9×10^9 cells per litre.

(b) The mean number of virus-like particles (VLPs) from n=7 ballast tanks was 7.4×10^9 VLPs per litre (standard error = 2.3×10^9), ranging from 0.6×10^9 to 14.9×10^9 VLPs per litre.

Conclusions & Recommendations

11 Considerable variation exists in the concentrations of organisms arriving in unexchanged/untreated ballast water among vessels. Some of this variation is explained by (a) season and (b) voyage duration. Several studies also indicate that considerable variation exists among ballasting events, within the same port and season, which undoubtedly contribute to the observed variation.

12 The median concentrations of organisms estimated by this analysis for unmanaged ballast water provide a useful frame of reference in consideration of ballast water standards.

(a) The median is one approach to characterize the distribution of concentrations observed in unmanaged ballast water, as it presently arrives.

(b) By definition, 50% of all ballast tanks sampled in this analysis had concentrations below the median value and the other 50% had concentrations above the median.

(c) A significant risk of invasions still exists at the observed median concentrations.

13 To significantly reduce the risk of invasions associated with ballast water beyond the present situation, permissible discharge concentrations identified by any treatment/management standards should fall greatly below the median values observed presently in untreated / unmanaged ballast water.

14 Any standard should strive to reduce the transfer of organisms to the maximum extent possible, to minimize the likelihood of invasions, as it is clear that the risk of invasion (a) exists with any organism transfer and (b) increases with increasing concentrations of organisms.

15 Recognizing the inherent risk with any discharge, and the current concentrations delivered in untreated ballast water, SGBOSV recommends standards at least 3 orders of magnitude below the observed median concentrations for zooplankton and an equivalent or higher level of reduction for phytoplankton.

(a) **Zooplankton**

The median was 0.4 individuals per litre (see above) what is equivalent to 400 individuals per cubic meter. A three orders of magnitude reduction results in 0.4 individuals per cubic meter.

(b) **Phytoplankton**

The median was 13,300 phytoplankton cells per litre (see above). A three orders of magnitude reduction results in 13.3 individuals per litre.

***

ANNEX 2

Source of data compiled in database and used in analyses. Sample size refers to number of ballast tanks sampled.

Organism Type	Source	Number of Samples	Sieve Size (μm)	Geographic Region	Ship Types
Zooplankton					
	S. Gollasch	101	55	Germany	Container, Ro-Ro, Tanker
	G. Ruiz et al.	205	80	Eastern U.S.	Bulker
	G. Ruiz et al.	123	80	Alaska	Tanker
Phytoplankton					
	S. Gollasch	61	10	Germany	Container, Ro-Ro, Bulker
	T. McCollin	105	0 (not sieved)	Scotland	Bulker, Cargo, Tanker
	T. McCollin & I. Lucas	107	0 (not sieved)	England & Wales	Bulker, Container, Ro-Ro, Tanker
Bacteria					
	G. Ruiz, F. Dobbs, & L. Drake	11	0 (not sieved)	Eastern U.S.	Bulker
Viruses					
	G. Ruiz, F. Dobbs, & L. Drake	7	0 (not sieved)	Eastern U.S.	Bulker

***

ANNEX 3

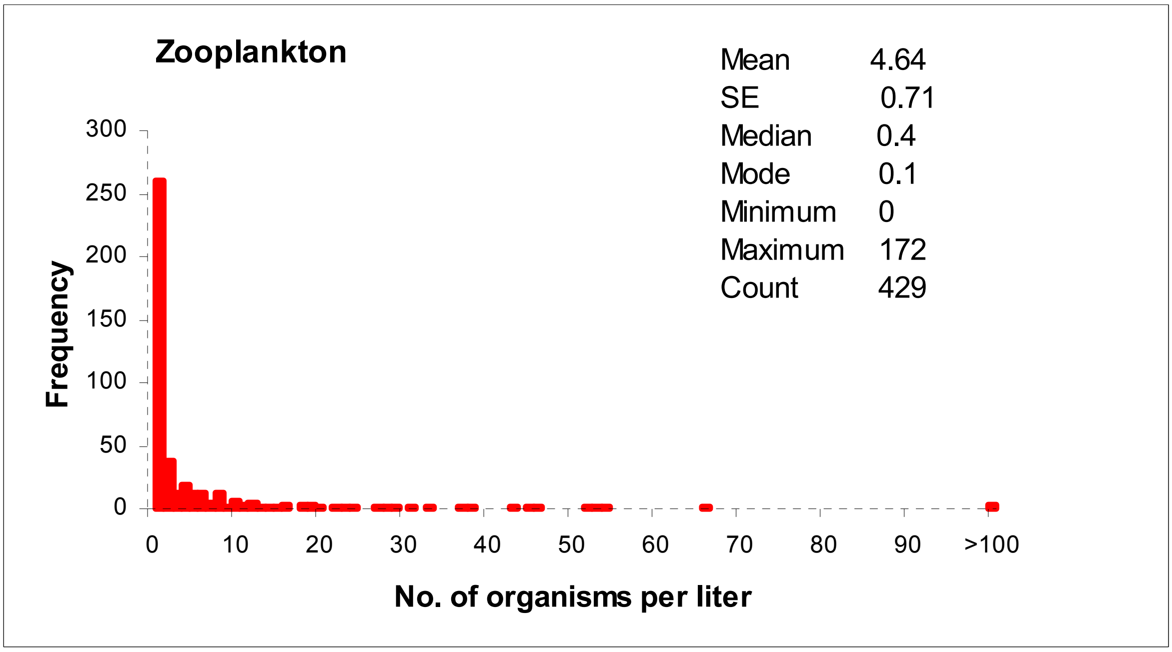

Figure 1. Frequency of zooplankton concentrations in ballast water. Shown is the frequency of zooplankton concentrations (no. per litre) measured in samples from ballast tanks (n=429).

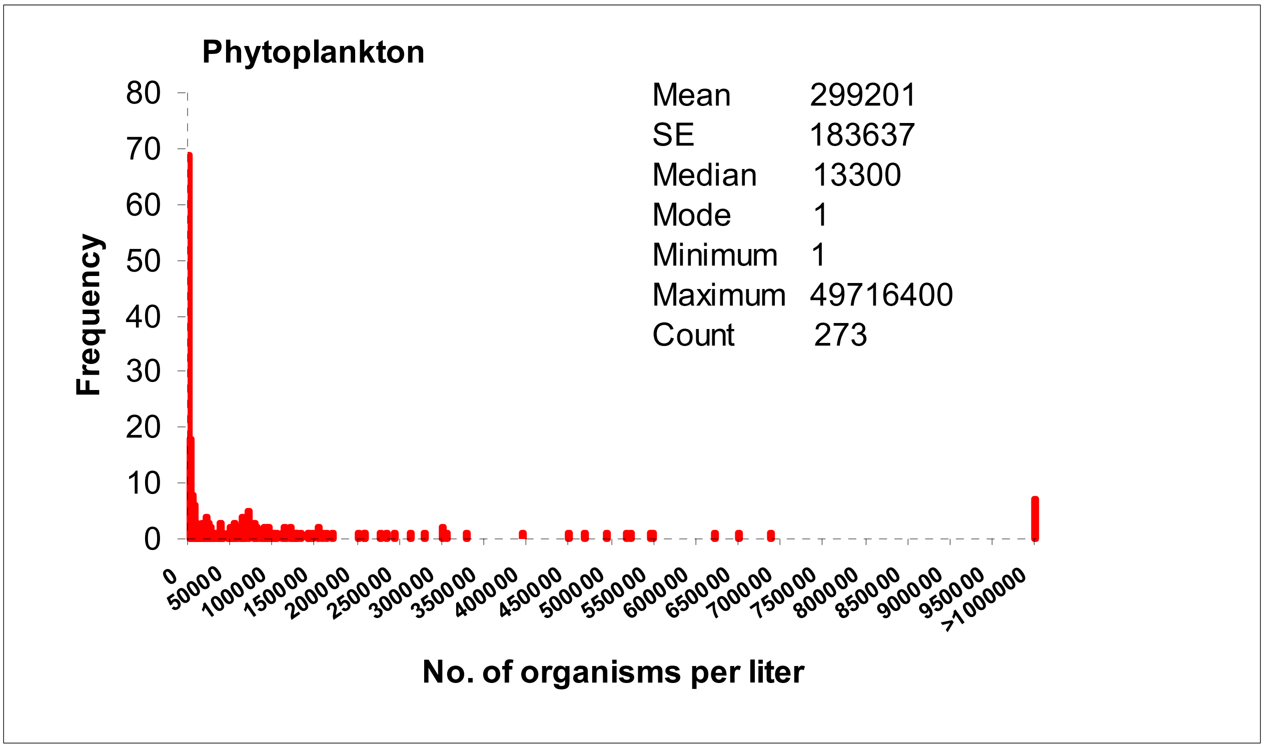

Figure 2. Frequency of phytoplankton concentrations in ballast water. Shown is the frequency of phytoplankton concentrations (no. per litre) measured in samples from ballast tanks (n=273).

***

ANNEX 4

List of participants at the 2003 meeting of SGBOSV in alphabetical order

Bahlke, Christian
GAUSS
Institute for Environmental Protection and Safety in Shipping gem. mbH
Werderstr. 73
28199 Bremen
Germany
T +49 421 5905 4850
F +49 421 5905 4851
gauss@gauss.org

Baumann, Juergen
Vancouver Port Corporation,
1900 Granville Square, 200 Granville Street
Vancouver, B.C. V6C 2P9
CANADA
T +1 604 665 9081
F +1 604 665 9007
juergen.baumann@portvancouver.com

Behrens, Hanna Lee
Environment and Specification Services (MTPNO362)
Maritime Technology and Production Centre
DNV
Veritasveien 1
1322 Høvik
Norway
T +47 67 57 82 90
F +47 67 57 99 11
Hanna.Lee.Behrens@dnv.com

Blatchley, Ernest
School of Civil Engineering
550 Stadium Mall Drive
Purdue University
West Lafayette, IN 47907-2051
United States
T +1 765 494 0316
F +1 765 496 1107
blatch@ecn.purdue.edu

Botnen, Helge
UNIFOB, Section of Applied Environmental Research
High Technology Centre
N-5020 Bergen
Norway
T +47 55 58 4465
F +47 55 58 4525
Helge.Botnen@ifm.uib.no

Cordell, Jeff
Wetland Ecosystems Team
University of Washington
Box 355 020
Seattle, WA 98195-5020
United States
T +1 206 543 7532
F +1 206 681 7471
jcordell@u.washington.edu

Cormier, Michael
Vancouver Port Authority
1900 Granvile Square
200 Granville Street
Vancouver, B.C. V6C 2P9
Canada
T +1 604 665 9086
F +1 604 665 9099
michael.cormier@portvancouver.com

Diederich, Susanne
Wadden Sea Station Sylt
Alfred-Wegener-Institute for Polar and Marine Research
Hafenstr. 43
25992 List/Sylt
Germany
T +49 4651 95 6133
F +49 4651 95 6200
sdiederich@awi-bremerhaven.de

Fuchs, Rainer
Degussa AG, Bleaching and Water Treatment Chemicals
Postcode 913-219
Rodenbacher Chaussee 4
63457 Hanau
Germany
T +49 6181 59 3892
F +49 6181 59 3311
rainer-g.fuchs@degussa.com

Gollasch, Stephan
Bahrenfelder Straße 73 a
22765 Hamburg
Germany
T +49 40 390 54 60
F +49 40 360 309 4767
sgollasch@aol.com

Hayes, Keith
CSIRO Centre for Research on Introduced Marine Pests, CSIRO Marine Loboratory
GPO Box 1538
Hobart, Tasmania 7001
Australia
F +613 6232 5485
Keith.Hayes@csiro.au

Herwig, Russell
School of Aquatic and Fishery Sciences
Box 355020
University of Washington
1122 Boat St. NE
Seattle, WA 98195-5020
United States
T +1 206 685 2163
F +1 206 685 7471
herwig@u.washington.edu

Hewitt, Chad
Ministry of Fisheries
PO Box 1020
Wellington
New Zealand
T +64 4 470 2582
F +64 4 470 2686
chad.hewitt@fish.govt.nz

Higgins, Mark
Department of Fisheries & Oceans
Pacific Biological Station
3190 Hammond Bay Road
Nanaimo, B.C. V9R 5K6
Canada
T +1 250 756 7072
F +1 250 756 7053
HigginsM@pac.dfo-mpo.gc.ca

Hunt, Carlton
Batelle
397 Washington Street
Duxbury, MA 02324
United States
T +1 781 952 5374
F +1 781 934 2124
huntc@BATTELLE.ORG

Hunter, Mike
Maritime Coastguard Agency, Spring Place
105 Commercial Road
Southampton, SO15 1EG
United Kingdom
T +44 2380 329 199
F +44 2380 329 204
Mike_Hunter@mcga.gov.uk

Jörgensen, Lis
NFH, University of Tromsö
Breivika
N-9037 Tromsö
Norway
T +47 77 64 4530
F +47 77 64 6020
lisj@nfh.uit.no

Kerckhof, Francis
Management Unit of the North Sea Mathematical Models
3 e en 23 e Linieregimentsplein
8400 Oostende
Belgium
T +32 59 24 2056
F +32 59 70 4935
f.kerckhof@mumm.ac.be

Kieser, Dorothee
Department of Fisheries & Oceans, Pacific Biological Station
3190 Hammond Bay Road
Nanaimo, B.C. V9R 5K6
Canada
T +1 250 756 7069
F +1 250 756 7053
kieserd@pac.dfo-mpo.gc.ca

Kornmüller, Anja
Sterling Berkefeld
Berkefeld-Filter Anlagenbau GmbH
Lückenweg 5
D-29227 Celle
Germany
T +49 5141 803 290
F +49 5141 803 201
a.kornmueller@berkefeld.de

Levings, Colin
Marine Environment and Habitat Science Division
West Vancouver Laboratory
4160 Marine Drive
West Vancouver, V7V 1N6
BC., Canada
LevingsC@pac.dfo-mpo.gc.ca

Manushin, Igor
Laboratory of Shellfish
Polar Research Institute of Marine Fisheries and Oceanography
6, Knipovicha Str.
Murmansk
Russia
T +7 815 247 2464
manushyn@pinro.murmansk.ru

McCollin, Tracy
FRS Marine Laboratory
PO Box 101, 375 Victoria Road
Aberdeen, AB11 9DB
United Kingdom
T +44 1224 876544
F +44 1224 295573
mccollint@marlab.ac.uk

McDowell, Karen
California Sea Grant Ext. Programme
1515 Clay St., Suite 1400
Oakland, CA 94612
United States
T +1 510 622 2398
F +1 510 622 2501
kdhart@ucdavis.edu

Minchin, Dan
Marine Organism Investigations,
3 Marina Village
Ballina, Killaloe, Co Clare
Ireland
T +353 86 60 80 888
minchin@indigo.ie

Miossec, Laurence
IFREMER
Laboratoire Génétique et Pathologie, DRV/RA
B.P. 133
17390 La Tremblade
France
T +33 05 46 36 98 36
F +33 05 46 36 37 51
Laurence.Miossec@ifremer.fr

Nilsen, Birgir
Optimarin AS
400 Main St. #714
Stamford, CT 06901
United States
T +1 203 973 0678
F +1 413 683 3240
bnilsen@optimarin.com

Occhipinti, Anna
University degli Studi di Pavia, Sezione Ecologia
Dipartimento di Genetica e Microbiologia
Via Sant Epifanio 14
27100 Pavia
Italy
T +39 0382 304610
F +39 0382 528496
occhipin@unipv.it

Pederson, Judith
Massachusetts Institute of Technology, Sea Grant
College Program
292 Main Street E38-300
Cambridge, MA 02139
United States
T +1 617 252 1741
F +1 617 252 1615
jpederso@mit.edu

Raaymakers, Steve
International Maritime Organization (IMO)
Global Ballast Water Management Programme
(GloBallast)
Programme Coordination Unit
4 Albert Embankment
London, SE1 7SR
United Kingdom
T +44 20 7587 3251
F +44 20 7587 3261
sraaymak@imo.org

Reid, Dave
National Oceanic & Atmospheric Administration
(NOAA)
Great Lakes Environmental Research Lab (GLERL)
2205 Commonwealth Blvd.
Ann Arbor, MI 48105-2945
United States
T +1 734 741 2019
F +1 734 741 2055
David.Reid@noaa.gov

Rosenthal, Harald
Schifferstraße 48
21629 Neu Wulmstorf
Germany
T +49 40 700 65 14
F +49 40 701 02 676
haro.train@t-online.de

Ruiz, Greg
Smithsonian Environmental Research Center
P.O.Box 28
Edgewater, MD 21037-0028
United States
T +1 443 482 2227
F +1 443 482 2380
ruizg@si.edu

Simard, Nathalie
Dep. of Fisheries and Oceans, Maurice Lamontagne
Institute
PO Box 1000, 850 Rue de la Mer
Mont-Joli, Quebec G5H 3Z4
Canada
T +1 418 775 0682
F +1 418 775 0718
SimardN@dfo-mpo.gc.ca

Sundet, Jan H.
Fiskeriforskning
Norwegian Institute of Fisheries and Aquaculture Ltd.
Centre of Marine Resources
9005 Tromsö
Norway
T +47 77 62 9000
F +47 77 62 9100
jan-h.sundet@fiskforsk.norut.no

Sutherland, Terri
Fisheries and Oceans Canada
Marine Environment and Habitat Science Division
West Vancouver Laboratory
4160 Marine Drive
West Vancouver, V7V 1N6
BC., Canada
T +1 604 666 8537
F +1 604 666 3497
sutherlandt@pac.dfo-mpo.gc.ca

Taylor, F.J.R. "Max"
Dept. of Earth and Ocean Sciences
Oceanography, University of British Columbia
Vancouver, B.C V6T 1Z4
Canada
T +1 604 822 4587
F +1 604 822 6091
maxt@unixg.ubc.ca

ten Hallers-Tjabbes, Cato
Royal Netherlands Institute for Sea Research (NIOZ)
P.O. Box 59
1790 AB den Burg
the Netherlands
T +31 222-369574 & +31-595-551772
F +31 222-319674
cato@nioz.nl

Verling, Emma
Smithsonian Environmental Research Center
Box 28
647 Contees Wharf Road
Edgewater, MD 21037
United States
T +1 443 482 2387
verlinge@si.edu

Voigt, Matthias
dr. voigt-consulting
Kampstr. 7
24601 Stolpe
Germany
T +49 4326 98737
F +49 4326 98738
m.voigt@drvoigt-consulting.de

Wallentinus, Inger
Department of Marine Ecology, Marine Botany
University of Göteborg
P.O. Box 461
405 30 Göteborg
Sweden
T +46 31 773 2702
F +46 31 773 2727
inger.wallentinus@marbot.gu.se

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APPENDIX 5: MEMO ON A NATURAL INVASION RATE STANDARD

Subject: **Basis for a Standard Based on the Natural Rate of Invasion**
To: Ballast Water Treatment Standards Committee
From: Andrew Cohen
Date: August 7, 2005

Biological Rationale for a Standard Based on the Natural Invasion Rate

Biological invasions of marine ecosystems are natural, at least in the sense that on rare occasions a coastal organism must have by accident drifted or rafted across the ocean and established an isolated colony on the other side. However, human activities—prominently including the transport and discharge of ballast water—have greatly increased the rate at which such colonies are established, creating a novel level of rapid alteration of ecosystems and (because a portion of these species have harmful impacts on economic or recreational activities or public health), elevated the stresses on human communities.

A performance standard that reduced the rate of invasion due to ballast water discharges to around the average rate of invasion under natural conditions would implicitly allow a doubling of the natural invasion rate as a result of ballast discharges alone. However, in contrast with a standard that allowed a 10x or 100x increase in the invasion rate,[1] this is still reasonably close to the natural rate and possibly within the normal range of variation, and would thus be reasonably protective of the environment. Because it would entail a substantial decrease in the current rate of invasion, it would also reduce the impacts on human uses. Such a standard would thus be reasonably protective of the various environmental, recreational and economic beneficial uses of California's waters.

Calculation of a Standard Based on the Natural Invasion Rate

To a first approximation, in order to reduce the rate of invasions due to ballast water to roughly the average natural invasion rate, we need to reduce the concentration of living organisms in ballast water discharges by the ratio between the natural invasion rate and the invasion rate due to the discharge of untreated and unexchanged ballast water.[2] We'll call this ratio the Reduction Factor:

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1 Based on the calculations below, the standards in S. 363 and S. 1224 represent about a 10x-100x increase over the natural invasion rate for organisms >50 microns, and about a 100x-1,000x increase for organisms in the 10-50 micron size class. The standards in the IMO Convention represent about a 1,000x-10,000x and about a 10,000x-100,000x increase over the natural invasion rate for >50 micron and 10-50 micron organisms, respectively.

2 This approximation implicitly assumes that the Discharge/Invasion Curve is roughly linear, that is, that an X% increase or decrease in the number of organisms discharged during a period of time will

$$\text{(1)} \qquad \text{Reduction Factor} = \frac{\text{Natural invasion rate}}{\text{Invasion rate due to untreated and unexchanged BW}}$$

Then, the concentration standard for living organisms in ballast water discharges that will meet this goal is:

$$\text{(2)} \qquad \text{Concentration Standard} = \frac{\text{Concentration of organisms in}}{\text{untreated \& unexchanged BW}} \text{ X } \text{Reduction Factor}^{3}$$

Estimate of concentration in ballast water: Order-of-magnitude estimates of the concentration of living organisms in untreated and unexchanged ballast water at the end of transoceanic voyages are:

- for organisms >50 microns in width 10^2-10^3 per m^3
- for organisms 10-50 microns in width 10-10^2 per mL
- for organisms <10 microns in width 10^8-10^9 per 100 mL

These estimates are derived from statistical data on studies that sampled ballast water of coastal origin that had not been exchanged or treated. Specifically, the concentration

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produce about an X% increase or decrease in the number of invasions that occur during that time as a result of those discharges. We don't, in fact, know the shape of this curve and a variety of shapes are theoretically possible, but the assumption of linearity is both the simplest possible assumption and consistent with standard regulatory practice. For example, the US EPA routinely makes the precisely analogous assumption when assuming that the Dose/Response Curves for a variety of suspected carcinogens and other toxins are linear in order to extrapolate responses from rodent bioassays conducted at high dose levels to chronic human exposures projected at low dose levels.

3 In reality, it's not the *concentration* of organisms in ballast water that needs be reduced by the Reduction Factor, but rather the *rate* at which organisms are discharged. This is equal to the concentration of organisms times the rate of ballast water discharge. If C_{BW} = the concentration of organisms in untreated, unexchanged ballast water, D_1 = the rate of ballast discharge during the baseline period that corresponds to C_{BW}, and D_2 = the rate of ballast discharge during the future period when the Concentration Standard is in effect, then:

$$\text{Concentration Standard} \times D_2 = C_{BW} \times D_1 \times \text{Reduction Factor}$$

If $D_1 = D_2$, then this equation reduces to Equation (2). If the rate of ballast water discharge is decreasing over time ($D_1 > D_2$), then Equation (2) will calculate a Concentration Standard that is too low (*i.e.* too stringent), and if it's increasing, it will calculate a standard that is too high (too lenient). For the container fleet, the increasing number of Post-Panamax ships, which carry and discharge less ballast water per ship while carrying more containers suggests that the rate of ballast water discharge could decline (Herbert 1999). For example, the Port of Oakland (1998) projected that while the number of containerships arriving at the Port and the amount of cargo carried by them would increase from 1996 to 2010, the amount of ballast water they discharged would decrease by 42%. On the other hand, for other types of vessels such as bulk carriers and tankers, significant decreases in the amount of ballast water discharged per ton of cargo are unlikely (Herbert 1999). The larger volumes of ballast water carried by these ships, and the projected increases in cargo tonnage handled by California ports suggests that the overall rate of ballast discharge will increase. In neither case, however, is the change likely to approach an order of magnitude, and so Equation (2) seems reasonable as a first approximation.

ranges for >50 micron and 10-50 micron organisms are based on the mean and median values for zooplankton and phytoplankton samples, respectively, and the concentration range for <10 micron organisms is based on the mean values for bacteria and virus-like particles. More detail on these data is provided in Table 2 of "Attachment F: Comparison of Potential Standards" which SLC sent to the Committee before the July meeting, in Greg Ruiz's presentation at the April meeting, and in MEPC (2003).

Estimate of natural invasion rate: A natural marine invasion is defined as a marine organism that is transported across an ocean by drifting, rafting or some other natural, irregular and rare transport mechanism and becomes established initially as a disjunct, isolated population in waters on the other side. It excludes organisms that have a continuous range that includes both sides of the ocean (such as, in the Pacific, organisms that have a continuous range from northern Japan and Siberia across to Alaska and British Columbia by way of the Bering Strait or the Aleutian Islands), organisms that have regular, natural genetic exchange between populations on opposite sides of the ocean (such as may occur with pelagic organisms that regularly migrate across the ocean, or organisms with teleplanic larvae that are regularly advected across the ocean), and organisms occurring in disjunct, transoceanic populations that are relics of formerly genetically-continuous populations. The natural, one-way invasion rate (*i.e.* from one side of the ocean to the other) can be estimated as:

$$(3) \qquad \text{Natural invasion rate} = \frac{0.5 \times \text{The number of species common to both sides of the ocean that are thought to result from natural invasion}}{\text{The length of time it takes for isolated populations to become morphologically distinct}}$$

Based on a review of the biogeographical literature and other relevant data, the number of species of invertebrates and fish[4] common to both sides of the Pacific Ocean that are thought to be the result of natural invasions is estimated as ≤10 (J. Carlton estimate) or ≤100 (A. Cohen estimate). The length of time that it takes for isolated populations of invertebrates or fish to become morphologically distinct (*i.e.* such that they would be considered separate species based on morphological evidence) is estimated as 1-3 million years.[5] If we conservatively[6] estimate the number of naturally invaded

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4 The available biogeographical data for other types of organisms, including protozoans, fungi, bacteria and viruses, are too poor to provide a basis for even a rough estimate of the natural invasion rate.

5 For example, closely-related populations of marine organisms on either side of the Panamanian isthmus, which have been separated for about 2.8 million years, are variously considered by taxonomists to have morphologies that range from being very similar but capable of being distinguished (and therefore are considered separate species) to being so similar that they cannot be distinguished (and therefore are usually identified as the same species).

In the July meeting, Greg Ruiz noted that Vermeij (1991) reported that 11 gastropod species from the western Pacific had invaded the eastern Pacific in the last 18 million years. This rate of 0.6 invading gastropods per million years seems reasonably consistent with an estimate of ≤100 fish and invertebrates per million years.

6 In this memo, "conservative" is taken to mean supporting a smaller reduction from the concentration of organisms in untreated discharges and a less-stringent standard. Here, for example, it means using the numbers—out of the range of reasonable estimates—that produce the highest estimate of natural invasion rate. If the calculation instead used 10 for the number of common species and 3 million years for the period, the natural invasion rate would be less than 2 species per million years.

invertebrate or fish species common to both sides of the ocean to be 100, and the relevant period to be 1 million years, then the natural invasion rate from the western to the eastern Pacific shore for species in these two categories of organisms is 50 species per million years, or 5×10^{-5} species per year.

Estimate of invasion rate due to unexchanged, untreated ballast water: The Federal law that first set up a voluntary program of mid-ocean ballast water exchange was passed in 1996, and the California law that required mid-ocean ballast water exchange was passed in 1999. Data from a period immediately prior to the passage of these laws would therefore be appropriate for estimating the rate of invasion resulting from the discharge of unexchanged and untreated ballast water.

From 1961-1995, the rate of invasion into the San Francisco Bay and Delta was one species every 14 weeks, or 3.7 species per year; with the rate increasing over time to 5.2 species per year in 1991-95 (Cohen & Carlton 1997).[7] The fraction introduced by ballast water also increased over time. For invertebrates and fish, the rate was 2.9 species per year in 1961-1995, with ballast water responsible for introducing 0.7-1.7 species per year (24-59% of the total); in 1991-1995 the rate was 4.2 invertebrate and fish species per year, with ballast water responsible for 1.6-3.2 (38-76% of the total).

These figures probably substantially underestimate the true number of invasions, by missing exotic species that (a) haven't been collected, (b) have been collected but not identified, or (c) have been identified but whose status as exotic or native has not yet been resolved (cryptogenic species). These missing species could raise the total by probably 50-100%.[8] In addition, these figures refer only to species established in the San Francisco Bay/Delta system; if species established elsewhere in California are included, the total could rise by at least another 50-100%.[9] When these factors are taken into account, ballast water is estimated to be responsible for introducing 2-7 exotic invertebrates and fish into California waters each year if 1961-95 is used as the baseline for the estimate, and 4-13 invertebrates and fish if 1991-95 is used as the baseline.

Calculation of Reduction Factor and Concentration Standards: Using the above estimates and Equation (1), the Reduction Factor is:

- for the 1961-95 baseline: $0.7\text{-}2.5 \times 10^{-5}$
- for the 1991-95 baseline: $0.4\text{-}1.3 \times 10^{-5}$

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7 The invasion numbers discussed in this section are based on the date of discovery (first observation or collection) of the invading species.

8 For example, Cohen & Carlton (1998) reported 234 exotic species and at least 125 cryptogenic species established in the San Francisco Bay and Delta (cryptogenics equal to 53% of the number of exotics). Ashe (2002) reported (a) 360 exotic species, (b) 247 species considered cryptogenic but "most likely introduced," and (c) 126 taxa not identified to species but considered by researchers to most likely be introduced, in California coastal waters (categories (b) and (c) equaling 104% of the number of exotics).

9 For example, Ashe (2002: Figure 5) reported 190 exotic and 43 cryptogenic species in San Francisco Bay, but 360 exotic and 247 cryptogenic species statewide, or 89% and 474% over the San Francisco Bay numbers.

To an order of magnitude, the Reduction Factor is 10^{-5}.[10] The corresponding Concentration Standards are:

- for organisms >50 microns in width 10^{-3}-10^{-2} per m^3
- for organisms 10-50 microns in width 10^{-4}-10^{-3} per mL
- for organisms <10 microns in width 10^{3}-10^{4} per 100 mL

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[10] Steve Moore (San Francisco Bay RQWCB) noted that this is reasonably close to the reductions in organism concentrations that have been achieved for decades under the Safe Drinking Water Act, where the EPA criteria set reductions of 10^{-3} or 10^{-4} for different types of microbes.

APPENDIX 6: ADDENDUM TO THE MEMO ON A NATURAL INVASION RATE STANDARD

Footnote 5 incorrectly reported data from Vermeij (1991). Vermeij actually stated that 11 gastropod species from the Line Islands in the Central Pacific had invaded the eastern Pacific in the last 2 million years, or a rate of about 5.5 invading gastropods per million years. At the August 2005 Advisory Panel meeting, after some discussion of technical issues related to the records in this paper and other paleontological data, Greg Ruiz stated that he was more comfortable with a natural invasion rate estimate of ≤1,000 fish and invertebrates per million years. Thus, three invasion biologists provided the Panel with different estimates of the natural invasion rate, corresponding to calculations of different Reduction Factors and concentration limits, as follows:

Biologist	Estimate of natural invasions of invertebrates and fish per million years	Reduction Factor	Concentration limits for organisms >50 microns	Concentration limits for organisms 10-50 microns	Concentration limits for organisms <10 microns
J. Carlton	≤10	10^{-6}	10^{-4}-10^{-3}	10^{-5}-10^{-4}	10^{2}-10^{3}
A. Cohen	≤100	10^{-5}	10^{-3}-10^{-2}	10^{-4}-10^{-3}	10^{3}-10^{4}
G. Ruiz	≤1,000	10^{-4}	10^{-2}-10^{-1}	10^{-3}-10^{-2}	10^{4}-10^{5}

The Panel considered the wider range of concentration limits indicated by this range of estimates as potentially pertaining to a natural invasion rate standard.

APPENDIX 7: MEMO ON TECHNICAL FEASIBILITY, TREATMENT COSTS AND ECONOMIC INDICATORS

Subject: **Some Data on Treatment Costs and Economic Indicators**

To: Ballast Water Treatment Standards Committee

From: Andrew Cohen

Date: August 7, 2005

Technical Feasibility and Scale

The basic task to be achieved is to remove or kill organisms that are trapped in a tank of water.

Relative to the volumes handled by existing programs to remove or kill organisms in water or wastewater, the amount of ballast water to be treated is modest. Less than 7.8 million cubic meters of ballast water were discharged into California waters in 2004 (Falkner *et al.* 2005). In contrast, over 3.2 *billion* cubic meters of wastewater are treated and discharged to the San Francisco Bay Estuary each year (Gunther *et al.* 1987)[11], or more than 150 times the volume of ballast water discharged to the entire state. Each year, 24 different wastewater treatment plants in the Bay Area each treat more than the total volume of ballast water discharged to the entire state. Two Bay Area plants each treat more than 23 times the total volume of ballast water discharged to the entire state.

Comparable or even larger volumes of water are treated by the Bay Area's water districts.

From the perspective of water or wastewater treatment, treating all of California's ballast water is a small-scale project — the volume equivalent of a single small water treatment plant for the entire state.

[11] These data are from a 1987 review, based on wastewater treated in 1984-86. With 20 years of rapid population growth, the volume of wastewater treated in the Bay Area is no doubt substantially larger today.

Estimated Treatment Costs for all Ballast Water Discharged into California

The figure below from URS/Dames & Moore 1998 is from a study commissioned by the California Association of Port Authorities that included site-specific cost estimates for essentially all ports in the state. The other figures were developed by multiplying per metric ton costs derived from the cited sources by the State Lands Commission's data on the total amount of ballast water discharged into California waters in 2004 (7.8 million metric tons—Falkner *et al.* 2005). For the most part, these studies estimated the major, identifiable costs but did not necessarily estimate all costs. Costs given in Australian or Canadian dollars were converted to US dollars using recent exchange rates. Costs were not inflated to current dollars.

	$million/year
Filtration & UV (onshore)	
AQIS 1993	2-5
Pollutech 1992	3-9
URS/Dames & Moore 1998	8
Chlorine (500 ppm)	
Pollutech 1992	13
Rigby *et al.* 1993	19
Filtration & UV (shipboard)	
Pollutech 1992	22
Schilling 2002	32
Hydrocyclone & UV (shipboard)	
Schilling 2002	27
Glutaraldehyde	
Lubomudrov, Moll	32-48
Glycolic Acid	
RNC Consulting	50

Shipping Industry - Economic Indicators

CALIFORNIA-WIDE INDICATORS

- Cargo handled by California Ports
  - $260 billion in 2003 (DOT Statistics 2003)
  - $300 billion/year (ILWU)

- Revenues, Costs & Profits of California Shipping Industry (rough calculation based on comparison with Jones Act Fleet data)
  - Revenues ≈$14 billion/yr
  - Capital & Operating Costs ≈$12.5 billion/yr
  - Profits ≈$1.5 billion/yr

PORT/REGION INDICATORS

- Bay/Delta ports: $34 billion in foreign trade in 1992 (Port of Oakland 1998a, b)
- Annualized net direct benefit of -50' dredging project to ships using the Port of Oakland:
  - $156-229 million/year (Port of Oakland 1998a)
- Federal subsidy for Port of Oakland's -50' dredging project:
  - $82.5 million (Port of Oakland 1998b)

PER VESSEL INDICATORS

- Capital & Operating Costs per Vessel

Containerships:	$10,000-15,000/day – new 1,000-3,500 TEU (OCS 2004)
	$42,000/day while in port, $53,000/day while at sea – 73,000 DWT containership (Port of Oakland 1998c)
Bulk Carriers:	$11,000-19,000/day – various ages & sizes (OCS 2004)
	$24,000/day – 10-year-old Capesize (Stopford)
Tankers:	$32,000-43,000/day – new VLCC (OCS 2004)

- Profits per Vessel

Containerships:	$3,000-27,000/day – 300-3,500 TEU (OCS 2004)
Bulk Carriers:	$15,000-38,000/day – various sizes (OCS 2004)
Tankers:	$9,000-32,000/day – various sizes (OCS 2004)

- Average Tanker Freight Rates
  - $19,000-$55,000/day (2002-2004) (Naval Institute 2005)

OTHER

- Shipping Industry – Net Profit Margin of 28.0%, the 2nd highest of 212 industries listed (2nd only to Healthcare Re-insurers) (Yahoo Finance, accessed Aug. 5, 2005).
- Shipping Industry – Return on Equity of 33.6%, the 9th highest of 212 industries listed (Yahoo Finance, accessed Aug. 5, 2005).

Shipping Industry - Growth Trends

Los Angeles/Long Beach harbors
In 1995, Long Beach Harbor and Los Angeles Harbor were the 2nd and 3rd busiest container ports in the US, after New York/New Jersey Harbor (Port of Oakland 1998c).

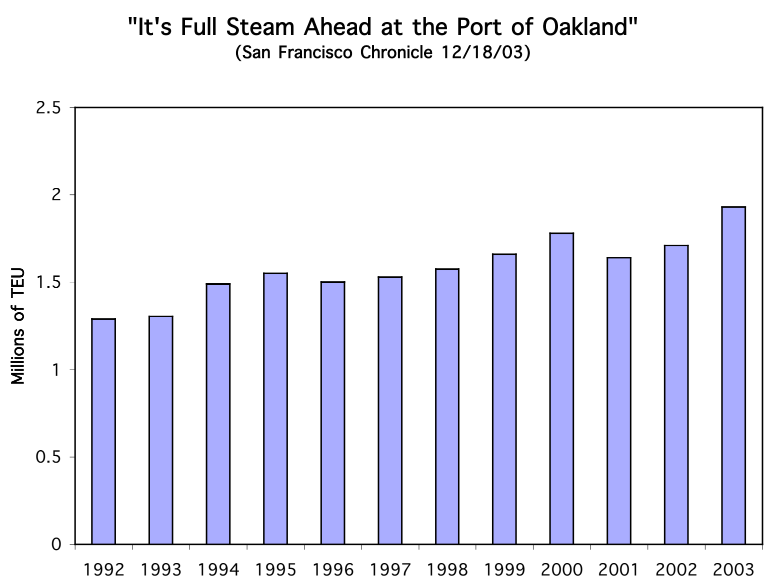
The number of containers handled at Long Beach Harbor more than doubled between 1994 and 2004, from 2.6 million to 5.8 million, for an average growth of 8.35% per year (data from "Attachment B: Economic Trends" in the materials provided by SLC for the July meeting).

Container traffic at Los Angeles/Long Beach harbors is expected to rise 13% this year, according to the Pacific Maritime Association (San Francisco Chronicle, July 15, 2005).

Port of Oakland
In 1995, the Port of Oakland was the 4th busiest container port in the US and the 19th busiest container port in the world (Port of Oakland 1998c).

Cargo tonnage at the Port of Oakland has grown 8.3%/yr over the past 5 years (Port of Oakland 1998c).

Projected growth is from 1.4 million TEU in 1996 to 3.4 million TEU in 2007. Future growth is projected at 7-8% per year (Jordan Woodman Dobson 1998).



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APPENDIX 8: MINORITY REPORT FROM PANEL MEMBERS REPRESENTING THE SHIPPING INDUSTRY

June 15, 2005

Suzanne Gilmore
Marine Facilities Division
California State Lands Commission
100 Howe Avenue, Suite 100 South
Sacramento, CA 95825

Re: California Public Resources Code – Ballast Water Performance Standards

Dear Suzanne:

Pursuant to the SB 433 (Nation – statutes of 2003), the State Lands Commission (Commission) has convened and consulted with an advisory panel to develop a report to the Legislature with recommendations on specific performance standards for the discharge of ballast water. The undersigned companies, representing many of the vessels calling in California's ports, appreciate the opportunity to participate in this process. We have worked closely with one another in an effort to ensure that the maritime industry's concerns and interests are adequately expressed within the framework of the advisory panel and more broadly, within the statute. We would like to offer the following recommendations to the panel as guidelines for the development of these standards.

The development of performance standards for discharge of ballast waters is one of the most important steps to take in the development of treatment technology. Although many public and private sector efforts have been made, and are currently underway to develop and analyze treatment technologies, establishing a standard for removal or destruction of invasive species will provide a benchmark for further development and refinement. However based on the data presented in previous panel meetings, the quantification of open water exchange efficiency as well as development of alternative treatment technologies are still in the infancy stages. Data on the correlation of microorganism concentrations in ballast water and the introduction of invasive species are also scarce. Therefore, we recommend caution in developing performance standards without sound scientific testing and analysis. We fully support provisions that will allot CSLC the necessary funding to develop the data needed to make defensible decisions regarding ballast water performance standards.

Efforts to develop standards are taking place in the international arena, through the International Maritime Organization (IMO) as well as nationally through both federal legislation and research being done by the United States Coast Guard (USCG). Our industry applauds the efforts by the Commission to coordinate and align the California ballast water statutes and regulations with the USCG and the IMO. As the majority of ocean going vessels entering California waters operate throughout the world, the adoption of harmonious regulations results in greater ease of application, less disruption to industry and most importantly - greater compliance. In the case of ballast water management, the shipping industry has been exposed to a variety of state and local requirements that, in some cases, have varied from international and federal requirements. Continuing this patchwork-quilt approach would be catastrophic for the environment and the industry and undermine the progress that we can make on this issue by the establishment of a strong, uniform federal program. Although California's major ports are some of the largest in the world, it is unrealistic to assume that capital investment will be put toward technology to treat ballast water to a standard different from the rest of the world. We can not foresee multiple treatment systems on-board vessels, each treating to a different standard.

For this reason, our suggestion to the advisory panel is to await the development of standards from the USCG or the IMO and consider those standards as guidelines for a recommendation to the Legislature. We realize that such standards may not be available for review prior to the January 31, 2006 deadline established under AB 433, however our understanding is that work is already being done on these and any delay should be minor. We also believe the Commission has the ability to provide the Legislature with an interim recommendation to await national or international standards and to act upon those standards once in place.

We will be happy to discuss this recommendation further with the advisory panel.

Sincerely,

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John Berge – Pacific Merchant Shipping Association

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Lisa M. Swanson – Matson Navigation Company

____

Bradly Chapman – Chevron Shipping Company

APPENDIX 9: SUPPLEMENTAL REPORT FROM THE OCEAN CONSERVANCY

Advocates for Wild, Healthy Oceans

Pacific Regional Office
116 New Montgomery St.
Suite 810
San Francisco, CA 94105

415.979.0900 Telephone
415.979.0901 Facsimile
www.oceanconservancy.org

Formerly the Center for
Marine Conservation

September 9, 2005

Lt. Governor Cruz Bustamante
California State Lands Commission
100 Howe Ave Suite 100 South
Sacramento, CA 95825-8202

The Ocean Conservancy

Dear Lt. Governor Bustamante and Members of the Commission:

At the outset, The Ocean Conservancy would like to thank the State Lands Commission for convening this Committee, and its staff for their skillful facilitation of the Committee's activities. Although The Ocean Conservancy supports many of the Majority Report's recommendations, we write separately to highlight a few points.

(1) California Should Adopt A Rigorous, Technology-Forcing Approach.

As the Majority Report indicates, the Committee selected more-or-less fixed "interim" standards that are achievable given technologies that are available today. Simultaneously, the Committee selected an implementation schedule – one that is aligned with other federal programs – that gives the industry years before any substantive improvement must be made. During the Committee's work, TOC sought higher standards because the existence of such standards – combined with a competitive marketplace for ballast water treatment products – would motivate the rapid development of technology appropriate for meeting them.

The Clean Water Act has been termed a technology-forcing statute because of the rigorous demands placed on those who are regulated by it to achieve higher and higher levels of pollution abatement under deadlines specified in the law. The general statutory scheme is that in any given category or subcategory of industry, dischargers are to meet technology-based performance standards, based on the capability of available treatment technology. In other words, as technology develops and more effective pollution control tools become available, the requirements for dischargers are ratcheted up. Technology-based standards are the principal vehicle for setting pollution control levels, yet water quality standards were retained as a basis for assessing the need for even more stringent discharge controls where necessary to protect the uses of a stream, including human health. Accordingly, the Act specifically envisions **better** pollution control than "Best Available Technology Economically Achievable" in circumstances where water quality is impaired.

The interim standards selected by the Committee are as strong or stronger than any existing standards that we are aware of. However, they are fixed, inflexible and based on technologies available today, rather than flexible, forward-looking and adaptive. The Ocean Conservancy encourages the State Lands Commission to take the interim standards as a starting point, and to consider an approach that permits improvement of the standards – consistent with improvement in technology – over time.

(2) The Long-Term Discharge Standard of Zero Should Be Firmer.

The Ocean Conservancy supports the Majority Report's long-term standard of zero detectable discharge of living organisms because implementation of this standard is the only means of eliminating all risk of invasion. However, no date is set for achieving this standard, and the technical review conducted in 2016 will evaluate only **if** this standard can be met.

California must set a date for achieving the zero discharge standard, and establish benchmarks for reviewing the feasibility of the standard as it approaches. This approach would create incentives for developing technology as quickly as possible, without creating unmanageable compliance burdens for the industry.

(3) California Should Lead the National Battle Against Invasive Species By Adopting the Strongest Possible Standards.

California ports handle between $200 billion and $300 billion in cargo annually, and the estimated gross revenues of California shippers are in the range of $14 billion a year. California is the 6th largest economy in the world. In other words, the assertion that shippers will avoid California ports if California's ballast water performance standards are too stringent is a scare tactic. Moreover, it is a scare tactic that has a long history.

California's air quality legislation predates the federal Clean Air Act, and set higher standards that persist today. California's water quality legislation predates the federal Clean Water Act, and controls pollution from a wider variety of sources even today. California's pesticide regulation predates federal insecticide controls, and even today, California's pesticide regulations are the most comprehensive in the nation. These are just a few examples of California's environmental leadership, but they are sufficient to highlight the fact that strong environmental regulation has never caused industry to flee from this state. Despite tough rules, our economy continues to grow.

* * * * *

In sum, TOC encourages the State Lands Commission to continue its pattern of national leadership in addressing the threat of invasive species in United States waters. The recommendations of the Ballast Water Performance Standards Advisory Committee are strong, but could be made significantly stronger, as we outline above. Most importantly, California should not wait for the emergence of national standards that are heretofore unsettled. Instead, it should do as it has historically done: lead the way, and encourage the rest of the nation to follow.

Sincerely,

Sarah G. Newkirk

Sarah G. Newkirk
California Water Quality Programs Manager